OLQ Geological Services
Technical Memorandum
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A General Outline of Bioremediation

This is not a comprehensive text, but rather a short overview, with notes as to applications and general effectiveness. Bioremediation is remediation commonly resulting from microbial action. Normal soils are replete with a huge range of naturally occurring microbes which interact in a complex micro-ecosystem. Although concentrated hydrocarbons (free product) and solvents may kill almost all microbes, some species will feed on and degrade many less concentrated contaminants. Bioremediation is the most active force in natural attenuation. Active bioremdiation methods involve some attempt at improving the speed or efficiency of natural bioremediation. Corrective action plans using bioremediation need to be evaluated on a site by site basis because what will work one place may not at another. However, some general statements may be made about various methods, which can be divided into ex-situ and in-situ bioremediation.

EX-SITU BIOREMEDIATION

This is bioremediation taking place after the contaminated soil is excavated and removed. It may be expensive, mostly due to the cost of digging and hauling the soil. It disrupts the site and requires a good deal of room. Ex-situ bioremediation is, however, usually far more successful than in-situ bioremediation. The act of excavation breaks up the natural soil packing and dramatically increases permeability and porosity. Air is naturally added as the soil is churned up, and most of the effects of soil conditions and chemistry are controllable. This alone is usually enough to greatly stimulate microbial action.

Land farming relies on excavation and mechanical stimulation for remediation. The soils are spread out and tilled occasionally to aerate the soil and break up clumps so microbes can work more effectively, and volatiles escape. It is usually successful and inexpensive for hydrocarbon clean-ups, but does require much open space.

Biocells (or biomounds) are soil treatment units which are used to make remediation faster, and use less space than land farming. Most cells are covered to control moisture and temperature, and some utilize an air delivery system to increase oxygen. Nutrients are often added. Many companies promote varied chemicals, secret formulas, added microbes, or special nutrients to supposedly improve bioremediation, but the specialty additions are not essential, and may not be cost-effective. Minnesota has developed an extremely efficient biocell which uses manure for nutrients. Promotional claims should not be accepted; any additives specified in a corrective action plan should be carefully evaluated to see if they would actually be a cost-effective improvement.

Bio-reactors are treatment tanks filled with microbial solutions which are used to clean water or

air. These are quite specialized for each application, and require much experience and engineering.

IN-SITU BIOREMEDIATION

This is in-place bioremediation, (aerobic and anaerobic) without excavation. In-situ bioremediation is far more complex, difficult to control, and less successful than ex-situ methods. Many additives and bioremediation systems are on the market, but success usually depends on site conditions, and it is extremely difficult or impossible on many sites for a delivery system to reach all affected areas. Extra monitoring requirements are usually necessary to ensure that remediation is progressing.

Natural attenuation, as mentioned above, is usually present at all sites, and is often the main limiting factor in contaminant plume movement. This is NOT a "walk-way" or "no-action" remediation. Thorough site characterization and monitoring is mandatory. Due to inherent site conditions (permeability, pH, temperature, oxygen levels, other soil and groundwater chemistry, and type and amount of contamination), natural attenuation may be exceedingly slow. Active in-situ bioremediation methods are attempts to overcome one or more of the limiting factors.

Biostimulation is the addition of something in an attempt to increase the activity of the naturally occurring microbial population. This can range from the addition of nutrients to the increase of oxygen. This category includes **bio-venting** (or biosparging), the pumping of air through the soil and/or groundwater to increase oxygen. It also includes chemical additives such as oxygen, calcium or hydrogen peroxide, and nitrogen or fertilizer additions.

Some forms of biostimulation seem to work fairly well, others do not. All are quite dependant on site conditions, none can be applied successfully at every site. Corrective action plans must be complete and extremely detailed as to the product, amounts, application methods, monitoring, reapplication needs and final testing. To just list a product name, without detailing how it will be used, is completely inadequate.

Bioaugmentation is the adding of additional microbial cultures. Unless a site has been completely sterilized, there are microbial cultures already in place, with a complex interaction of species. The activities of one species may provide nutrients for another. Some species often live on others, or their waste streams. Some species will degrade hydrocarbons much better at higher contaminant levels, while other microbes function at lower levels. A whole suite of cultures are usually needed to ensure a complete progression to cleanup. The absence of one or two critical species can dramatically slow site remediation.

Adding extra microbes from the outside, even from cultures taken from the site, overburden the site population and change species proportions. In many cases, the lab-cultured microbes cannot survive in the foreign and possibly hostile environment (EPA/540/S-94/502). Also, microbes may prefer to eat other microbes rather than contaminants, so adding more microbes can lead to the destruction of some beneficial indigenous species. Actual field tests have shown that bioaugmentation can more than double remediation time, compared to the control section of the site which was not treated.

In spite of the fabulous claims from some salesmen, the EPA does not recommend using bioaugmentation on sites which already have a viable microbial population (EPA/542/F-92/009) and also states “It is essential that independently-reviewded data be examined before employing a commercially- marketed microbial supplement”(EPA/540/S-94/502). Although microbial cultures have been applied on numerous sites, Geological Services has not been able to validate a case in Indiana where in-situ bioaugmentation has proven effective, and agrees with the EPA.